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POLYCHLORINATED DIBENZO-P-DIOXIN AND POLYCHLORINATED DIBENZOFURAN MONITORING NETWORK:

STANDARD OPERATING PROCEDURES AND TECHNICAL MANUAL

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POLYCHLORINATED DIBENZO-P-DIOXIN AND POLYCHLORINATED DIBENZOFURAN MONITORING NETWORK: STANDARD OPERATING PROCEDURES AND TECHNICAL MANUAL

Report prepared by:

Air Resources Branch
Ontario Ministry of the Environment

APRIL 1991

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PREFACE

Based on groundwork completed by the Canadian Council of Ministers of the Environment (CCME: formerly the Canadian Council of Resource and Environment Ministers) Dioxin Study a trial network was established in 1988 to measure ambient levels of polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF).

The major objectives of the program are:

1) To monitor ambient levels of PCDD and PCDF at selected sites in Ontario.

2) To determine background levels of PCDD and PCDF in areas where future activities may lead to increasing ambient levels (i.e. construction/operation of incinerators).

This manual describes the standard operating procedures for the network and should be used in conjunction with the Quality Assurance Plan. The manual is based on results from the above-mentioned CCME work and guides, papers, reviews, and internal correspondence from network operations. Input from regional personnel who operate the samplers and laboratory personnel who analyze the samples is gratefully acknowledged.

Throughout the manual the terms "dioxins" and "furans" are used interchangeably with PCDD and PCDF. If specific compounds are referred to, the full name will be used followed by the generally accepted short form in brackets which will be used thenceforward.

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1.0 Description of the PCDD/PCDF Sampler

1.1 General Description

Polychlorinated dibenzo-p-dioxins (PCDD) and polychlorinated dibenzofurans (PCDF) are two classes of semi-volatile organic compounds (SVOCs). SVOCs may be defined as compounds that are too volatile for air filtration sampling but not sufficiently volatile for thermal desorption from solid sorbents (Lewis, 1986). This definition constrains the sampling method to an upstream filter to trap the higher chlorinated (less volatile) species followed by a downstream vapour trap to collect the lower chlorinated (more volatile) species.

A standard high-volume sampler is familiar to many people, is easy to operate, and is readily modified to accept a vapour trap downstream of the particulate filter. It is for these reasons that a modified high volume sampler has been selected as the appropriate instrument for the collection of PCDD and PCDF ambient air samples.

Air is drawn through a teflon-coated glass fibre filter which traps particle-bound compounds, and then through a polyurethane foam (PUF) plug which effectively traps vapour phase dioxins and furans. Exhaust air from the motor is vented well away from the sampler to prevent any possibility of re-sampling exhaust air.

1.2 Components of the Sampling Train

The assembled components of the sampling train are shown in Figure 1.1. Each component is described in detail below.

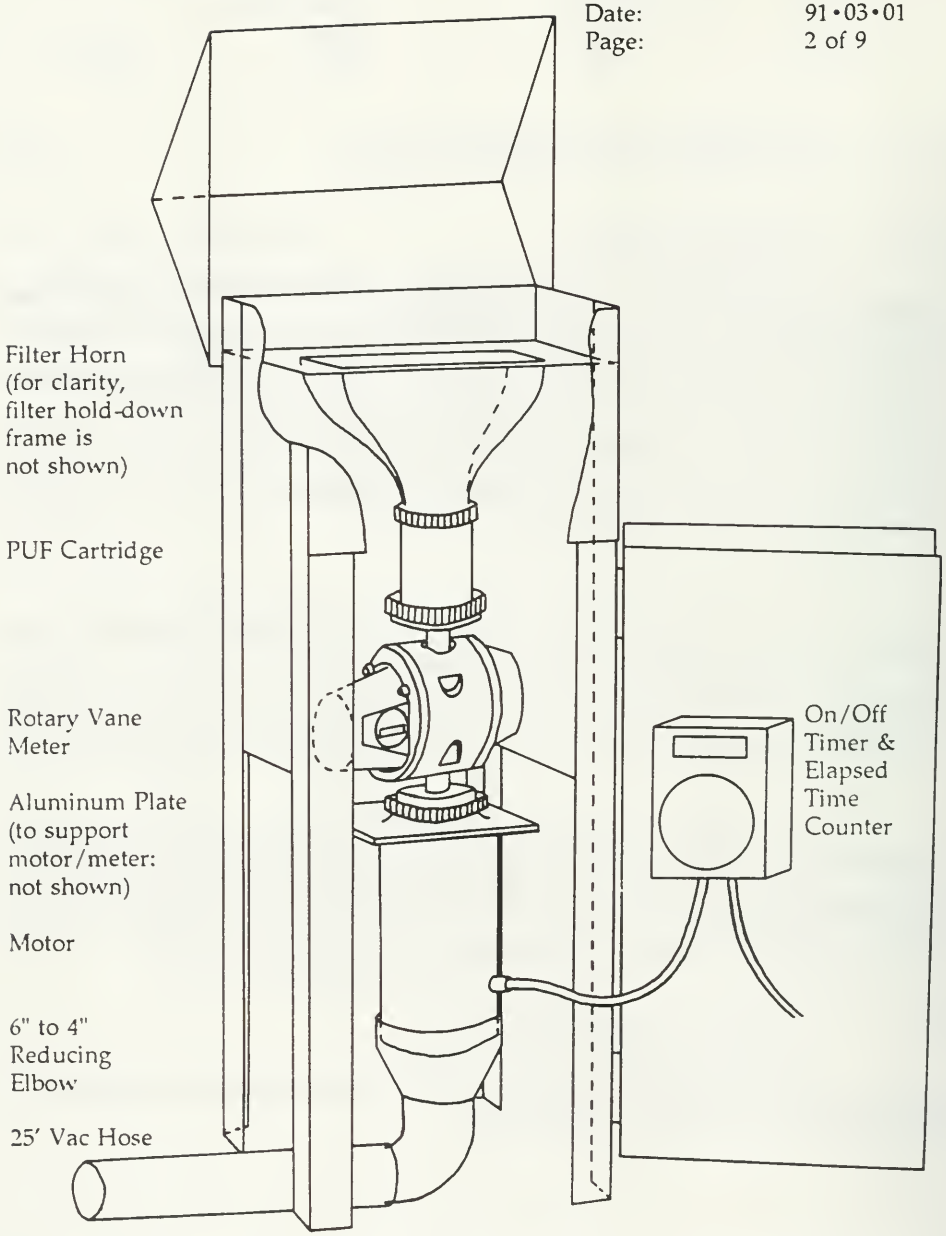


FIGURE 1.1. High Volume Sampler Modified for Dioxin/Furan Sampling.

1.2.1 The High Volume Sampler

A standard high volume sampler (HiVol) consists of an aluminum shelter with a "gabled-roof" type of lid; an aluminum filter hold-down frame with foam rubber gasket; a close-mesh filter support integrated into a "filter horn" which tapers to a threaded collar; a pump; and a timer/flow controller.

Several minor design problems are associated with the filter hold-down frame; these include: binding in cold weather; air leakage around the foam rubber gasket; and generally poor frame hold-down caused by the rounded top surface of the frame (the wing-nuts slip off). To remedy these problems the commercially available filter hold-down frame has been replaced with a cast aluminum frame with a flat top and two silicone rubber gaskets to provide a leak free seal around the filter (Figure 1.2).

The aluminum shelf at the bottom of the HiVol must be moved up and have a hole cut into it to facilitate mounting of the motor/rotary vane meter assembly.

1.2.2 The Timer

A standard HiVol flow controller/timer works on a 24 hr basis and so is unsuited to sampling for dioxins and furans, the low ambient levels of which dictate a longer sampling time. To achieve suitable detection limits a two day sampling period is preferred and hence a *MaxiRex QWT* seven-day time switch (Figure 1.3) is used to control the on/off function of the motor. When using this timer it is important to remove the sample promptly, otherwise the timer cycles through the week and turns the motor on again. The timer is installed on the door of the HiVol shelter where it is protected from the elements.

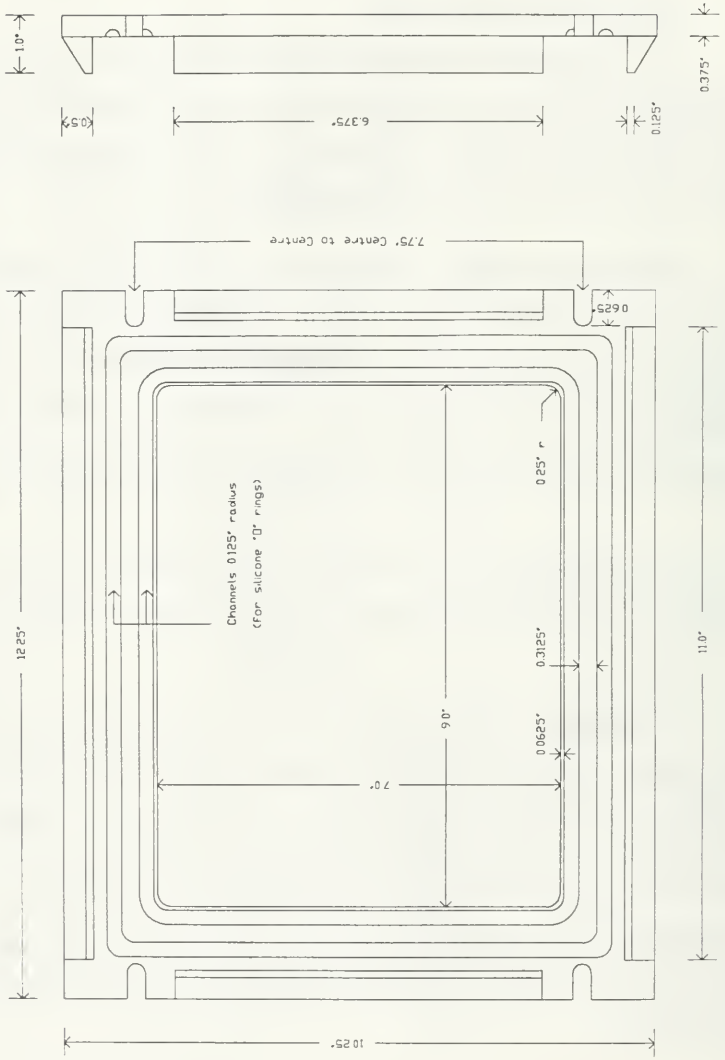


FIGURE 1.2. Filter Hold-Down Frame.

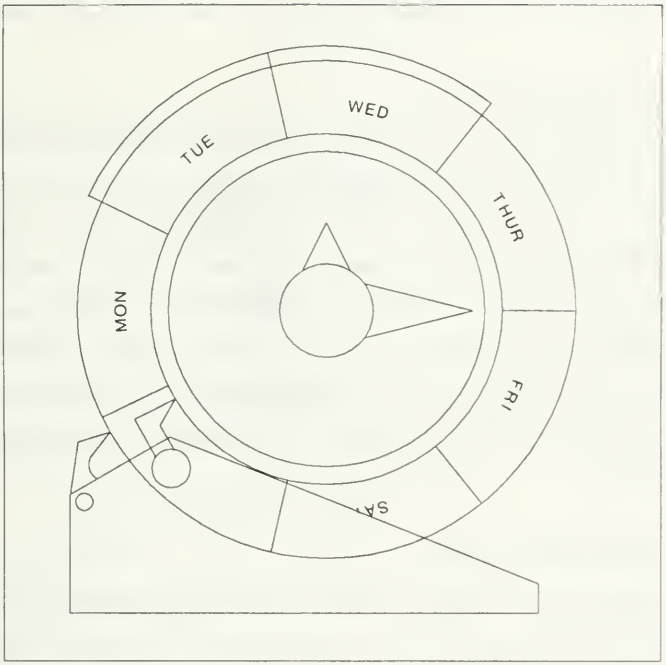


FIGURE 1.3. Maxi-Rex Timer.

1.2.3 Elapsed Time Indicator

The elapsed time indicator currently in use is manufactured by Hecon and runs off AC power. The timer is available at Electrosonic (Part No. GO-478-104) and costs about $50 with no installation hardware. The counter is resettable and may be operated continuously or by resetting the counter to zero before each sampling run.

1.2.4 Flow Measurement

Flow is measured by a rotary vane meter (Romet RM1500 rotary dry gas meter; Figure 1.4) mounted between the PUF cartridge and the HiVol motor (see Appendix 1 for mounting hardware). Sampled volume, in cubic feet, is displayed in the window mounted on the front of the rotary vane meter. The meter is shipped dry. ***After*** installation in the sampling train, light machine oil (ISO 10) must be poured into the two oil-fill ports, one on each side of the meter. The oil level should be visible half-way up the inspection window. The fill level should be checked periodically and topped up when necessary. ***At no time after filling with oil should the meter be in any other than a vertical position.***

1.2.5 The Sorbent Cartridge

The sorbent cartridge is custom made from aluminum, stainless steel, and nylon (Figure 1.5 and Appendix 1). The cartridge body is made from aluminum, the support screen for the polyurethane foam plug is a stainless steel mesh, and the floating collar (to attach the cartridge to the HiVol motor) is made from nylon: this is to prevent removal problems caused by binding when two aluminum parts are screwed together. The floating collar is scalloped around the perimeter to provide a grip when tightening or loosening the cartridge. Cartridge end caps of nylon are used during shipping and handling.

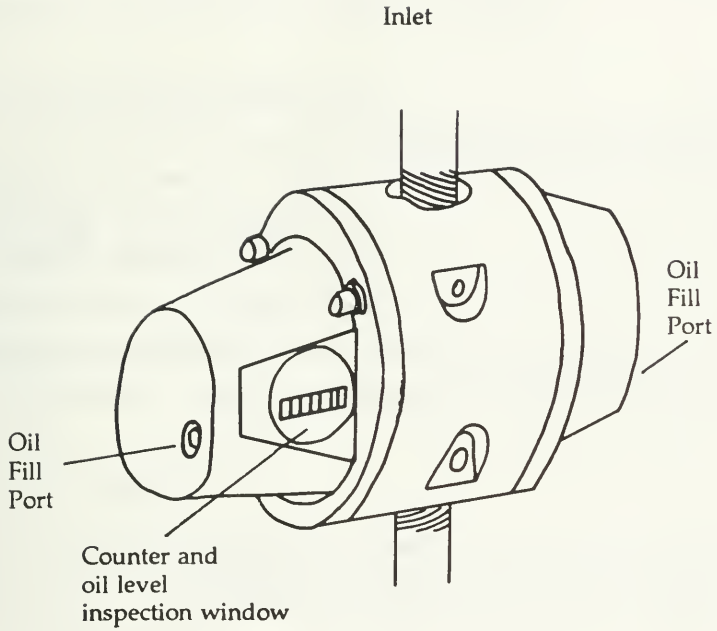


FIGURE 1.4. Rotary Vane Meter.

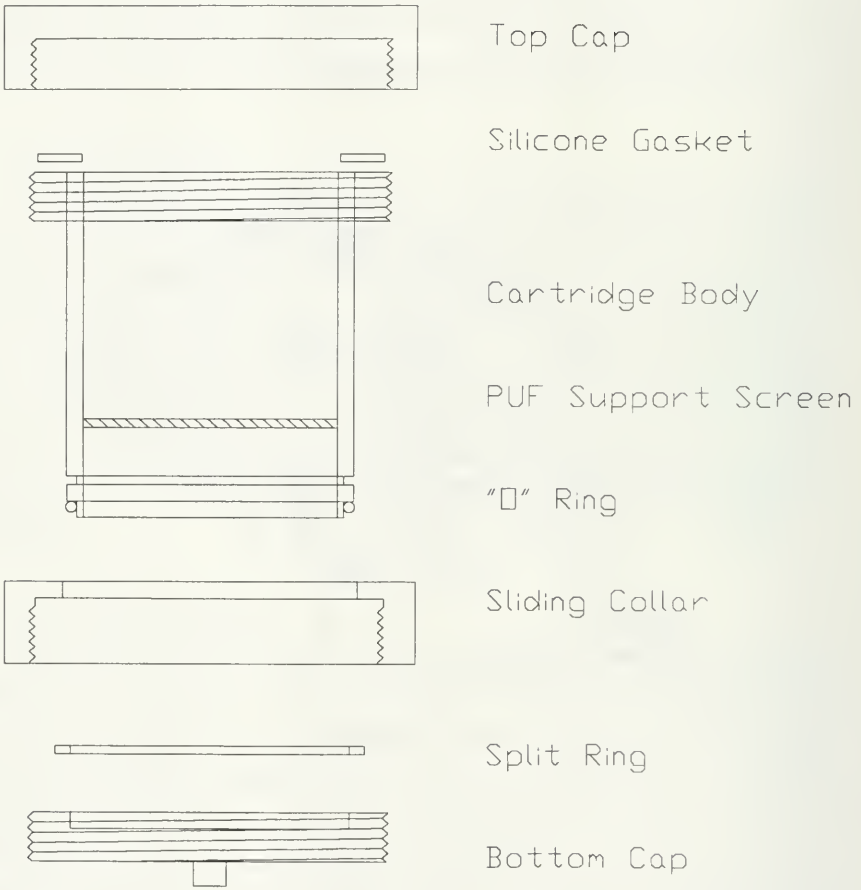


FIGURE 1.5. Cartridge to Hold Polyurethane Sorbent.

1.2.6 The Filter

The filter used for sampling dioxins and furans is an 8" x 10" teflon-coated glass fibre filter: Pallflex TX40HI20. These filters have a higher % efficiency than the previously used Pallflex T60A20 (Liu et al., 1983) and are the same as filters used by the Environmental Protection Service (Federal Government).

1.2.7 The Back-Up Vapour Trap

The vapour trap to back up the particulate filter is a plug of polyurethane foam 3 3/8" in diameter and 3" thick. The foam is open cell type with a specific density of 24.03 kg/m^3 (1.5 lb/ft^3) and a firmness factor of 31. The foam is available in slabs from furniture manufacturers (specified as Compression 15-31) and is cut to size in-house. This is accomplished using a hardened steel die mounted in a drill press. The die must be rinsed with methanol (twice) followed by dichloromethane (twice) prior to use. The cut foam plugs are sent to the laboratory for cleaning before use in the field.

1.3 References

Lewis, Robert G., 1986. Problems associated with sampling for semivolatile organic chemicals in air. Proc. EPA/APCA Symp. on Measurement of Toxic Air Pollutants. Raleigh, NC, April 1986, 134-145.

Liu, B.Y.H., D.Y.H. Pui and K.L. Rubow, 1983. Characteristics of air sampling filter media. Chapter 70 in: Aerosols In The Mining And Industrial Workplace, Vol. III, Ed. V.A. Marple and B.Y.H. Liu, Ann Arbor, MI, 1983.

2.0 Operation of the PCDD/PCDF Sampler

Detailed and specific operating instructions for a high volume sampler modified to collect PCDD/PCDF samples are provided below.

2.1 Sampler Set-Up Prior to Sample Collection

The procedures detailed below are to be followed when setting up the high volume sampler in preparation for the collection of a sample.

2.1.1 General

i) Plug the high volume motor into the timer/elapsed time indicator assembly (the timer/elapsed time indicator assembly should be fixed inside the HiVol shelter).

iii) Plug the timer assembly into an extension cord and lead the extension cord to an AC power outlet.

Clean filters are shipped wrapped in aluminum foil and are placed inside a protective aluminum clipboard available from stationery supply stores. Clean PUF plugs are shipped in cleaned aluminum cartridges sealed with the end caps. The filter horn from the active sampler is also cleaned after each sample and is shipped with the filter support screen covered with aluminum foil. ***No samples (cleaned or exposed) should be handled while smoking or in the vicinity of any smoking area.***

2.1.2 Specific

Detailed procedures for installing a clean filter and PUF cartridge and setting the timer are presented below.

2.1.2.1 Active Sampler

i) Fix the lid of the HiVol shelter in the open position.

ii) Remove the top end cap from the sorbent cartridge and place it in the cooler in which the clean equipment was shipped. Take care not to drop the gasket which is shipped in place under the top end cap.

iii) With the gasket centred on top of the sorbent cartridge, screw the locking ring of the filter horn down onto the threaded collar of the sorbent cartridge. The collar should be tightened firmly but DO NOT OVER-TIGHTEN as this creates problems when removing the sample.

iv) Remove the lower end cap from the sorbent cartridge and place it in the cooler in which the cleaned equipment was shipped. Take care not to drop the "o" ring which is shipped in place under the bottom end cap.

v) Lower the filter horn/cartridge assembly into position in the HiVol shelter.

vi) Screw the floating collar at the bottom of the sorbent cartridge onto the top of the rotary vane meter taking care not to cross the threads.

LEAK TEST THE ACTIVE SAMPLER: To leak test the active sampler, place a filter-sized sheet of plastic (acetate) over the filter horn. Turn the sampler on and watch the counter on the rotary vane meter. If it does not turn, there are no leaks in the system. If the counter does turn, shut the motor off and check all connections to ensure that they are tight and then repeat the leak test. It may be necessary to install the filter hold-down frame as well. *NOTE: Complete this leak test quickly! The motor is put under considerable strain at this time and should not be left on longer than it takes to ensure that the counter is not turning.*

vii) Wearing clean polyethylene gloves, remove the aluminum foil from the cleaned filter and centre the clean filter on the wire mesh support screen of the filter horn.

viii) Position the filter hold-down frame and tighten the wing nuts which hold it in place.

ix) Close the lid of the sampler.

2.1.2.2 Passive Sampler

The procedure for installing the passive sample is slightly different because there is no motor or rotary vane meter involved. The filter and sorbent cartridge are removed at the same time as the active sample. This represents a worst-case passive sample since no motor or exhaust hose is attached to the open bottom of the sorbent cartridge.

i) Fix the lid of the HiVol sampler in the open position.

ii) Remove the top end cap from the sorbent cartridge and place it in the cooler in which the clean equipment was shipped. Take care not to drop the gasket which is shipped in place under the top end cap.

iii) With the gasket centred on top of the sorbent cartridge, screw the locking ring of the filter horn down onto the threaded collar of the sorbent cartridge. The collar should be tightened firmly but DO NOT OVER-TIGHTEN as this creates problems when removing the sample.

iv) Remove the lower end cap from the sorbent cartridge, screw it onto the top end cap and place both in the cooler in which the cleaned equipment was shipped. Also place the "o" ring in the cooler for use when returning the exposed passive sample.

v) Lower the filter horn/cartridge assembly back into the HiVol shelter.

vi) Wearing the polyethylene gloves, centre a clean filter on the wire mesh support screen of the filter horn.

vii) Position the filter hold-down frame and tighten the wing nuts which hold it in place.

viii) Close the lid of the shelter.

The sampling train is now installed ready for the collection of a passive PCDD/PCDF sample. The next step is to set the timer to start, and then stop, the pump on the desired days.

2.1.3 Setting the Timer

An instruction sheet is shipped with every timer and this should be read for information about setting the timer. For the sake of convenience, the procedure for setting the timer is described below.

i) Push out all the blue pins on the inner dial. This is the 24 hr dial and is not used.

ii) On the outer dial, push out the blue pins corresponding to the sampling time and duration desired. For example; to sample for 48 hours starting at midnight on Tuesday, push out all the blue pins between 00:00 on Wednesday and 24:00 on Thursday (see Figure 1.3).

iii) Rotate the central knob (red) clockwise until the small white arm on the outer dial is opposite the current day and hour.

iv) Plug the unit in to AC power and it will now run from the current day and hour, turning the sampler on at the desired hour and day and off after the desired sampling duration.

2.1.4 Final Steps

i) Record the reading on the elapsed time indicator or reset it to zero. Enter the number on the sample submission/history form in the space provided (see Section 3.0 for complete instructions on filling in this form).

ii) Record the rotary vane meter reading in the space provided on the sample submission/history form.

All preparation steps are now complete and the instrument is ready to collect a PCDD/PCDF sample. The final check at this point is to ensure that the instrument shelter lid and door are closed.

2.2 Removal of the Exposed Sampling Train

Both the exposed and passive samples should be removed as soon after sampling has ended as is reasonably convenient. Prior to making the site visit a number of steps need to be followed.

2.2.1 Preparation

i) Remove freeze pack(s) from freezer and install in cooler.

ii) Ensure that all cartridge end caps and the lower gasket for the passive sampler are in the cooler.

iii) Also place in the cooler a pair of polyethylene gloves; new aluminum foil (it need not be cleaned first) and Zip-Loc bags to wrap the exposed filters in; a squeeze bottle of methanol; and the partially completed field sheet.

2.2.2 Removal of the Passive Sample

i) Open the door of the HiVol shelter and unscrew the sorbent cartridge from the filter horn taking care not to drop the gasket which is in place on top of the sorbent cartridge.

ii) Leaving the gasket in place on top of the sorbent cartridge, screw the top end cap firmly onto the sorbent cartridge. The sorbent cartridge may now be turned upside down and rested on the top end cap.

iii) Remove the spare "o" ring from the cooler and position it on the bottom of the sorbent cartridge.

iv) Place a bottom end cap on top of the "o" ring, slide the floating collar up and screw it onto the bottom end cap.

v) Affix a field sample number to the outside of the aluminum cartridge.

vi) Place the passive cartridge in the cooler.

vii) Raise the lid of the passive sampler and undo the wing nuts on the filter hold-down frame.

viii) Remove the filter hold-down frame taking care not to damage the filter.

Clean polyethylene gloves must be worn to perform the following steps.

ix) Carefully fold the filter in half with the exposed side in.

x) Wrap the filter in un-used aluminum foil and affix the second of the two identical field sample numbers to the outside of the foil (pre-printed sticky labels are provided for this purpose), and place the wrapped filter in a Zip-Loc bag in the cooler with the passive sorbent cartridge.

2.2.3 Removal of the Active Sample

The procedures for removing the active sample are similar to those described above for removing the passive sample, however, there are some differences due to the rotary vane meter attached to the bottom of the sorbent cartridge. All steps for removal of the active sample are described in detail below.

i) Record the rotary vane meter reading. Enter the number on the sample submission/history form in the space provided.

ii) Record the reading on the elapsed time indicator. Enter the number on the sample submission/history form in the space provided.

iii) Fix the lid of the active sampler in the upright position.

iv) Undo the wing nuts and remove the filter hold-down frame taking care not to damage the filter.

Clean polyethylene gloves must be worn to perform the following steps.

v) Carefully fold the filter in half with the exposed side in.

vi) Wrap the filter in un-used aluminum foil and affix a field sample number to the outside of the foil (pre-printed sticky labels are provided for this purpose) and place the wrapped filter in a Zip-Loc bag in the cooler.

vii) Unscrew the PUF cartridge from the top fitting on the rotary vane meter.

viii) Raise the filter horn/PUF cartridge assembly up out of the HiVol shelter and either rest it upside down on the ground or place it across the top of the open HiVol shelter.

ix) Make sure the "o" ring from the bottom of the PUF cartridge is still in place and position the bottom end cap over the exposed end of

the cartridge; slide the floating collar down and screw it onto the bottom end cap.

x) Unscrew the filter horn from the sorbent cartridge and place the filter horn in the cooler. Take care not to drop the gasket that is seated between the top of the sorbent cartridge and the filter horn. The filter horn is returned for cleaning before being used to collect another sample.

xi) Leaving the gasket in place on top of the sorbent cartridge, screw the top end cap firmly onto the sorbent cartridge.

xii) Affix the second of the two identical field sample numbers to the outside of the aluminum cartridge.

xiii) Place the active cartridge in the cooler.

NOTE: *If either the flat gasket or "o" ring are dropped during installation or removal of the sample they must be rinsed with methanol before being used either in the sampling train or to seal the PUF cartridge for shipment to the lab.*

Both the active and passive samples have now been collected and the cooler should contain the active sampler filter horn, 2 sorbent cartridges, and 2 foil-wrapped filters in Zip-Loc bags in the aluminum clipboard.

The final step is to ensure that the field sheet has been filled out correctly. Instructions to do this are detailed in the next section.

3.0 Sample Documentation

3.1 The Sample Submission/History Form

A form has been designed to ensure that all pertinent information about the sample is recorded. An example of the form is shown in Figure 3.1. The form combines the following two forms:

i) LIS Sample Submission Form

ii) LIS Request for Analysis Form

and also has additional space so that information that would normally be recorded on a separate field sheet may be included. The top box incorporates fields for all the information contained in the above-mentioned forms. Some of the fields are pre-printed, such as Sample Program Code; Lab; Pri; Sampling Agency; and the Primary Client Code. A list of valid Field Comment codes is printed on the back of the form.

3.2 Completing the Sample Submission/History Form

3.2.1 Submission Information - The First Box

The top box of the form contains the information previously coded on the LIS Submission Sheet. The fields are filled in as follows:

i) Submission No. - a seven character alphanumeric field to be completed by laboratory personnel. The first two characters will always be AT to indicate PCDD/PCDF ambient air sampling.

ii) Sample Program Code - a seven (7) or nine (9) digit integer representing the program, study, project, and sub-project (if used). Currently the sub-project is not used. This field is pre-printed on the form and will read 02 (Air Assessment and Abatement Program), 004 (Hazardous Contaminants Study), 04 (Dioxins and Furans Project).

iii) Lab. - this is pre-printed with the code "TR" for Toronto Lab (currently the

DIOXIN / FURAN SAMPLING PROGRAM
SAMPLE SUBMISSION/HISTORY FORM

SUBMISSION NO.: _____ SAMPLE PROGRAM CODE: 02 004 04

LAB: TR PRI: N FD TYPE: ___ SAMPLING AGENCY: 01 02 02 05 01 DATE SUBMITTED: ___/___/___

REGION: ____ TELEPHONE: _____ PRIMARY CLIENT CODE: AR019 COPIES TO: CLD03 / CLD06 /____/____

FIELD OPERATOR: _____ SUBMITTED BY: _____(print) _____(sign)

FIELD SAMPLE NO	SAMPLE TYPE	LABORATORY SAMPLE NUMBER	SAMPLE DATE ddmmyy	STATION ID NO	REMARK CODE	TEST GROUP	PLANNED COUNTER	TIME	TOTAL MINUTES	DRY GAS METER READING	VOLUME (M3)	FIELD COMMENTS
	FU					PEDIOX	START			START		
							END			END		
	FU					PEDIOX	START			START		
							END			END		
	FU					PEDIOX	START			START		
							END			END		
	FU					PEDIOX	START			START		
							END			END		
	FU					PEDIOX	START			START		
							END			END		
	FU					PEDIOX	START			START		
							END			END		

SPECIAL REMARKS:

Original to MOE Lab 1 Copy to Program Coordinator 1 Copy to Region

FIGURE 3.1. Sample Submission/History Form.

only valid code).

iv) Priority - this is pre-printed with the code "N" for normal (prior written permission is required for high priority submissions).

v) FD Type - this field is to be left blank.

vi) Sampling Agency - a ten (10) digit number representing the organizational unit responsible for collecting and shipping the samples. The digits are: Ministry (2); Division (2); Branch/Region (2); Section (2); and Unit (2). This field is pre-printed with the code for ARB which is 01 02 02 05 01.

vii) Date Submitted - a six (6) digit integer representing the day, month, and year on which the submission was *shipped* to the lab (rather than the date on which the sample was processed at the lab). This field is completed by field personnel.

viii) Region - the region in which the sample originated. Short form may be used; e.g. WC for West Central.

ix) Telephone - the telephone number, beginning with the area code, of the region in which the sample originated.

x) Primary Client Code - a five (5) character alphanumeric field. This is pre-printed as AR019 which is the client code for the program coordinator.

xi) Copies To - enter a maximum of four (4) client codes of people wishing to receive copies of the LIS output; e.g. Air Quality Chiefs.

xii) Field Operator - ***print*** the name of the person who actually collected the sample.

xiii) Submitted By - ***print*** the name of the person who actually submitted the sample (i.e. filled out the submission sheet) and then ***sign*** in the space provided.

3.2.2 Request For Analysis and Field Information - The Second Box

The second box on the form contains information previously coded on the

LIS Request For Analysis form and also provides space for recording field information pertinent to the history of the collected sample. Instructions for completing this section of the form are detailed below.

i) Field Sample Number - a five (5) or six (6) digit number assigned by the field operator. Paired numbers are supplied in rolls of self-adhesive labels. One number should be affixed to the aluminum cartridge containing the PUF plug and the other should be affixed to the foil containing the filter. The field operator must copy the field sample number into the appropriate space on the sample submission/history form.

ii) Sample Type - a code assigned by the lab. For the dioxins and furans sampling program the code is PU and this is pre-printed on the form.

iii) Laboratory Sample Number - this is a number assigned by laboratory personnel to keep track of the sample within the lab.

iv) Sample Date - a six (6) digit integer. Numeric day, month, and year on which the sample collection started. Days and months less than 10 should be coded with a preceding zero; e.g. the third of February, 1989 should be coded as 030289.

v) Station Identification Number - a five (5) digit integer. This number is assigned according to AQUIS protocol. Most PCDD/PCDF sampling sites will be installed at existing AQI sites and will use that station I.D. number.

vi) Remark Code - a field completed by lab personnel to record anything unusual about the sample.

vii) Test Group - the Test Group code is assigned by the lab and is pre-printed on the form as PEDIOX.

viii) Elapsed Time Counter - record the reading on the elapsed time counter before sampling starts and again after sampling ends. The counter may be reset before each sampling period so the "start" reading is always 000000 if so desired.

ix) Total Hours - a four (4) digit number representing the total number of hours that the sampler ran to two (2) decimal places; e.g. if the sampler ran for exactly 48 hours the total hours would read 48.00. ***NOTE:*** *the four digit representation assumes that the counter is reset to zero before each new sample.* This field may be Total Minutes if the elapsed time counter reads in minutes rather than hours.

x) Rotary Vane Meter Reading - an eight (8) digit number read directly from the rotary vane meter once at the start of the sampling period and once at the end of the sampling period.

xi) Volume - a five (5) digit number with one (1) decimal place obtained by subtracting the rotary vane meter start reading from the end reading to determine the number of cubic feet sampled and then converting the number to a value in cubic metres.

xii) Field Comments - an alphabetic character used to indicate any unusual sampling conditions. Valid field comment codes are listed on the back of the submission/history sheet. They are;

M - sampler Malfunction or sampling interruption

S - sampling Start time not 00:00 +/- 01:00 hr

F - Filter mis-handled during removal

I - cartridge mis-handled during Installation

R - cartridge mis-handled during Removal

G - cartridge missing upper or lower Gasket

As many codes as necessary may be used in the field comment space. If something affects the sample that is not covered by the listed field comments it may be described in the Special Remarks section (see below).

3.2.3 Special Remarks - The Third Box

The third section of the sample submission/history form is for recording any useful information not covered in the first two sections. The special remarks section may be used to expand on the field comment codes or to note when a new motor or rotary vane meter is installed etc. etc.

A1.1 Sorbent Cartridge

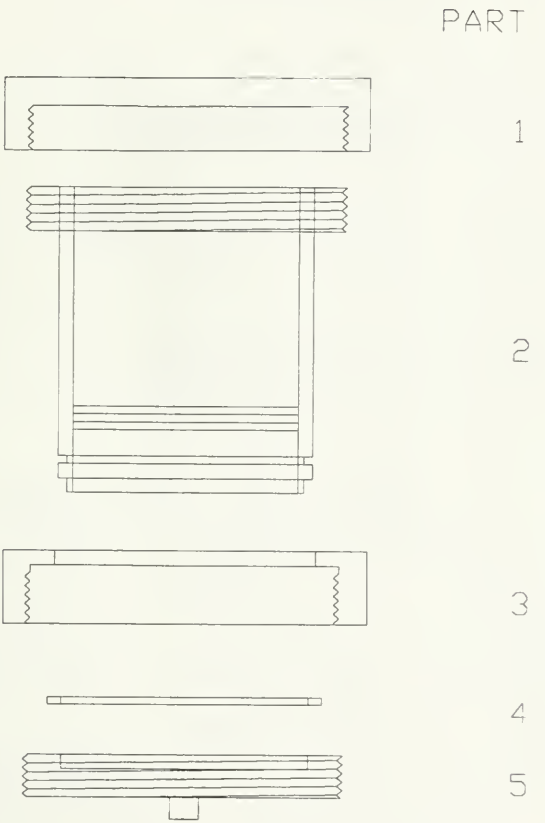


FIGURE A1.1. Sorbent Cartridge.

PART NO. 1

Top Transport Cap - Hard Nylon

Measurements from a working prototype may not be exact

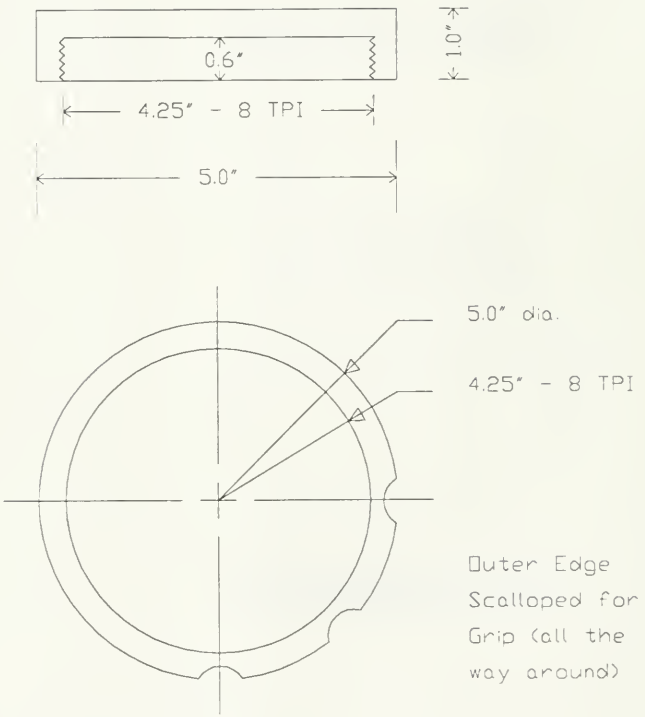
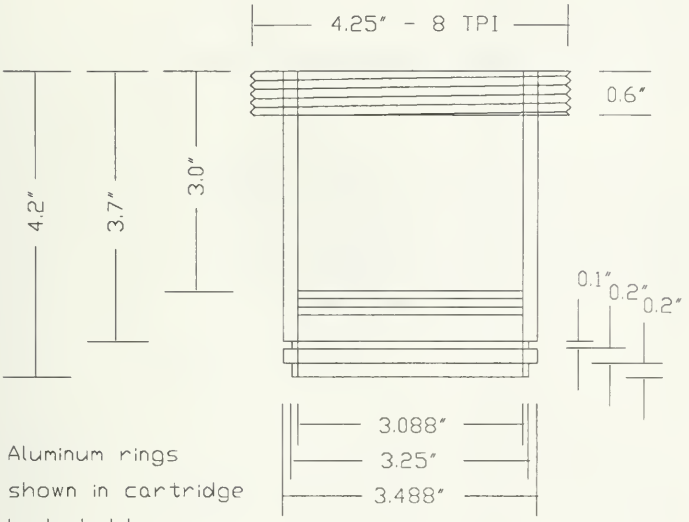


FIGURE A1.1.1. Top Transport Cap.

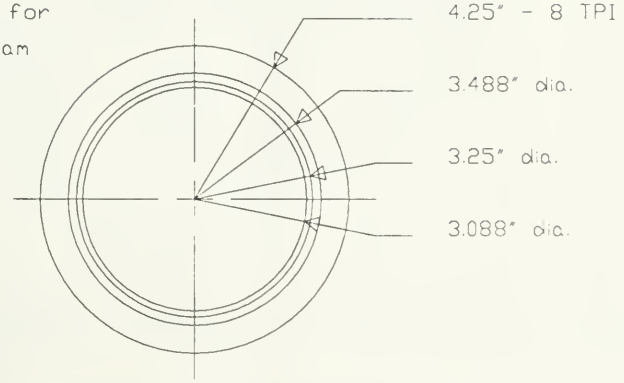
PART NO. 2

Cartridge Body - Aluminum

Measurements from a working prototype may not be exact



Aluminum rings shown in cartridge body hold stainless steel support screen for polyurethane foam plug.



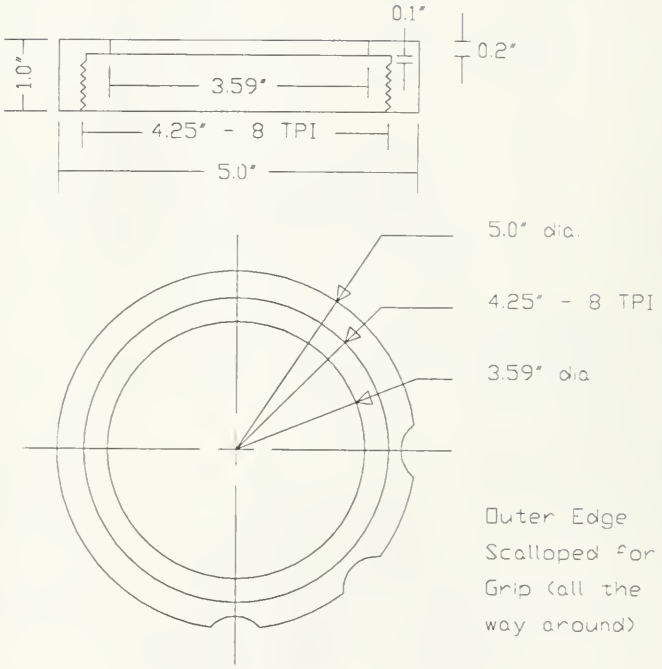
All threads straight (not tapered) and 8 threads per inch

FIGURE A1.1.2. Cartridge Body.

PART NO. 3

Sliding Collar - Hard Nylon

Measurements from a working prototype may not be exact



All threads straight (not tapered) and 8 threads per inch

FIGURE A1.1.3. Sliding Collar.

PART NO. 4

Split Ring - Stainless Steel

Mearurements from a working prototype may not be exact

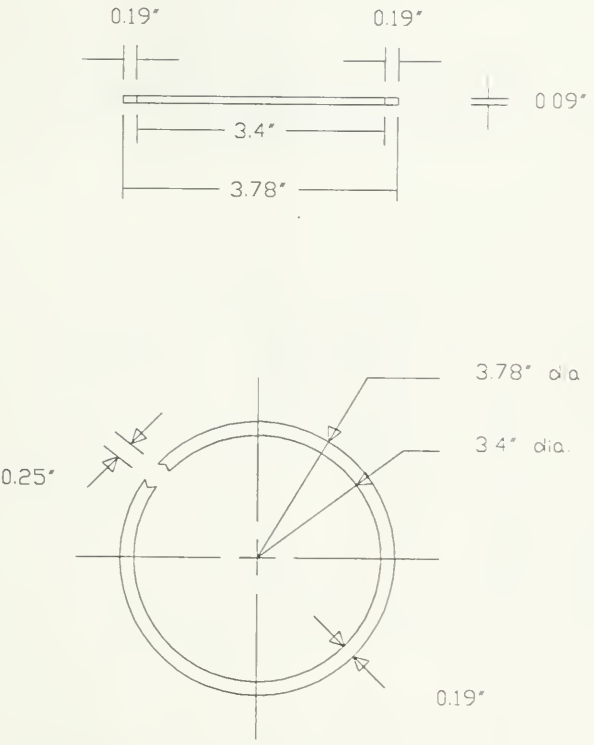
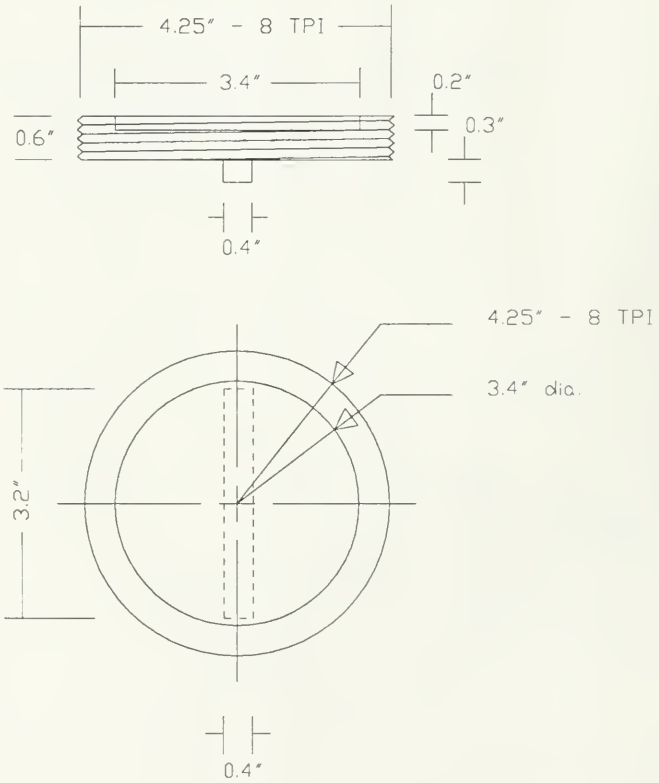


FIGURE A1.1.4. Split Ring.

PART NO. 5

Bottom Transport Cap - Hard Nylon

Measurements from a working prototype may not be exact



All threads straight (not tapered) and 8 threads per inch

FIGURE A1.1.5. Bottom Transport Cap.

A1.2 Rotary Vane Meter Fittings

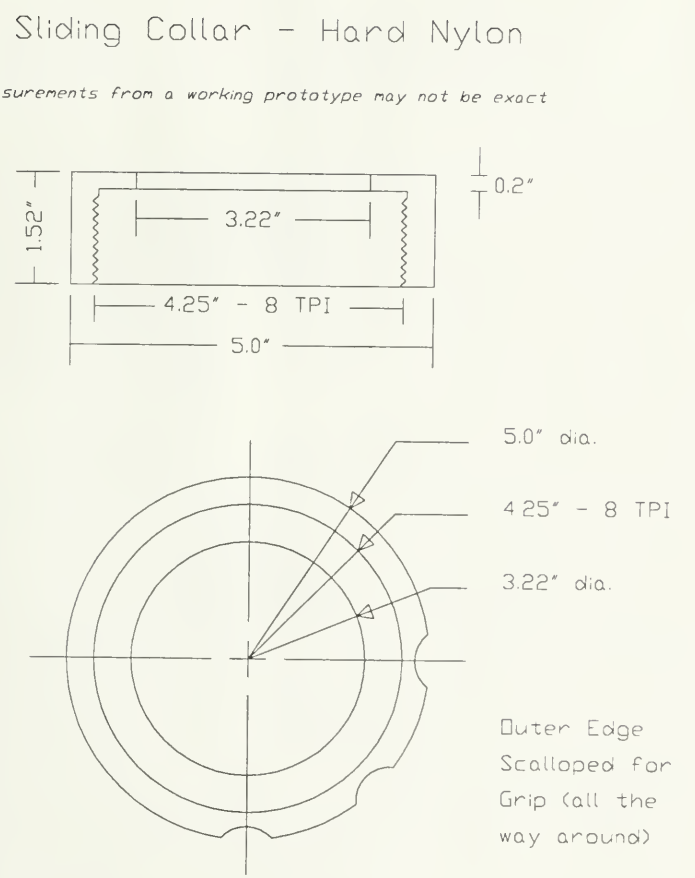

Sliding Collar - Hard Nylon
Measurements from a working prototype may not be exact
1.52"
3.22"
0.2"
4.25" - 8 TPI
5.0"
5.0" dia.
4.25" - 8 TPI
3.22" dia.
Outer Edge Scalloped for Grip (all the way around)
All threads straight (not tapered) and 8 threads per inch

FIGURE A1.2.1. Sliding Collar for Rotary Vane Meter.

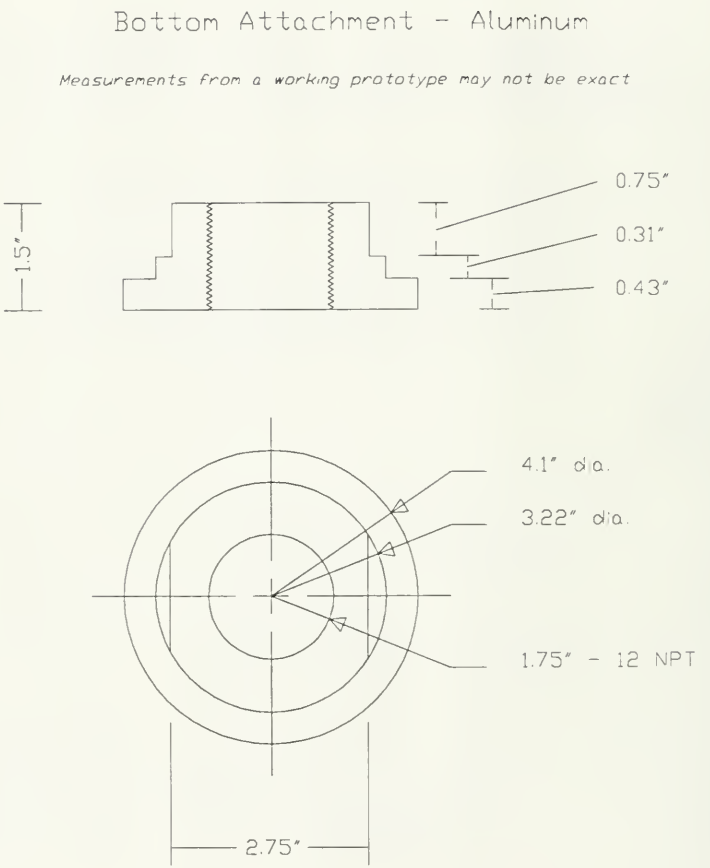

Bottom Attachment - Aluminum
Measurements from a working prototype may not be exact
1.5"
0.75"
0.31"
0.43"
4.1" dia.
3.22" dia.
1.75" - 12 NPT
2.75"
This part screws onto the bottom of the dry gas meter and holds the motor attachment collar in place

FIGURE A1.2.2. Bottom Attachment for Rotary Vane Meter.

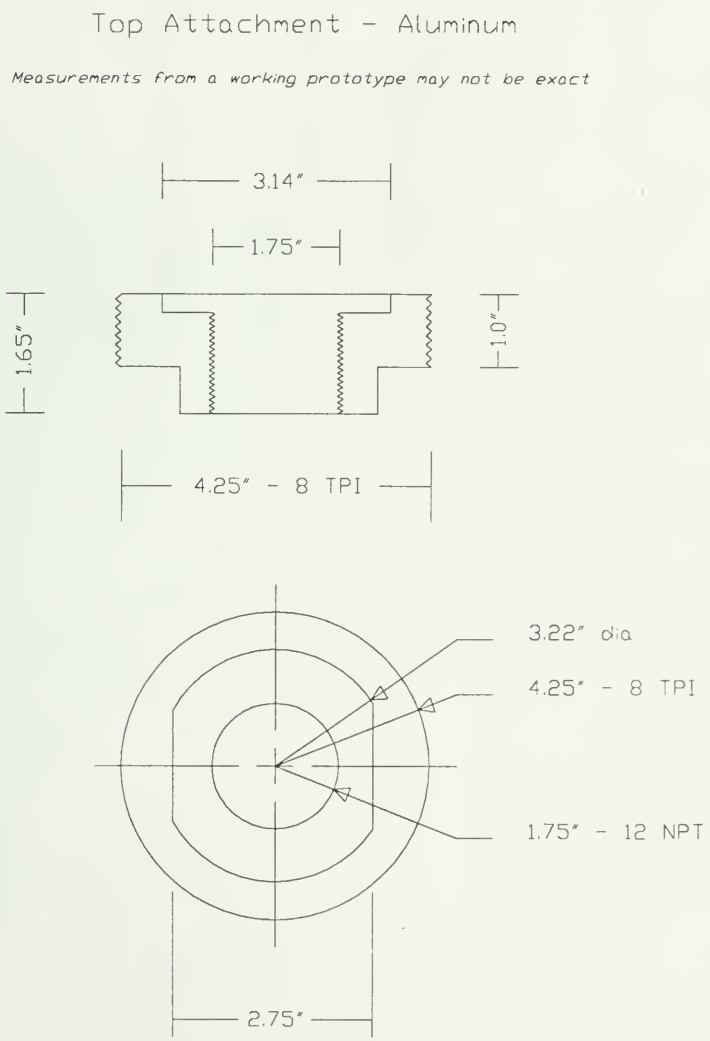


FIGURE A1.2.3. Top Attachment for Rotary Vane Meter.